TECHNICAL INFORMATION DIVISION
U. S. ARMY SIGNAL RESEARCH AND DEVELOPMENT LABORATORY
FORT MONMOUTH, NEW JERSEY

Radio signals from satellites, moon probes and other man-made space travelers are tricky things to hear, but Fort Monmouth's Astro-Observation Center not only receives all those audible in the United States. It records them as well.

The Astro-Observation Center is operated by the U. S. Army Signal Research and Development Laboratory, commanded by Col. W. McD. Brown, and consists of two basic sites. One is the location of the famous Diana moon radar at Belmar, N. J., and the other is nearby at Deal, N. J.

Space vehicle signals have been received and recorded by the Center since the first Soviet Sputnik was launched on October 4, 1957. Since then every announced space traveler whose voice could be received in North America has been heard. In addition, some odd, unannounced signals have been picked up and recorded.

The Center, which operates 24 hours a day, is credited with having the most complete library of space signals in the world, and it is available to scientists all over the country for detailed analysis of signal characteristics.

The constantly expanded Diana installation now has two giant antennas -- a 50-foot steel "dish", long used for moon-bounce experiments, and a new 60-foot paraboloid adapted for automatic tracking.

Faint, elusive signals received on these antennas come in as clearly as long distance telephone calls. Outstanding reception was obtained from the American Pioneer II in October of 1958, and the more recent Russian Lunik II. Unfortunately for U. S. stations, Lunik III transmitted signals only when interrogated from the other side of the earth.

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2--Astro-Observation Center

Reception of Lunik II signals, however, was an outstanding success at the Astro-Observation Center. Fort Monmouth listened and recorded confirmed signals from the moon probe on three frequencies: 183.6, 40 and 20 megacycles. No other station in the country reported receiving a single beep.

The 183.6 signal was received by the 60-foot antenna at the Camp site, while the lower frequencies were picked up by the companion station at Deal.

Seen from the highway, the Deal station looks like an "antenna farm," with corkscrew shaped helixes, conical helixes, spinning direction finders and the more conventional poles and wire spread over the acreage.

This array is necessary because some types of antennas are better for picking up signals initially, while others provide steadier reception for signal study.

Once acquired by one or more of the antennas, a signal is fed through a complex battery of converters, multicouplers, receivers, filters and recorders.

Since the received signals are studied and analyzed by many different persons for many purposes, they are recorded in a number of ways.

All signals are recorded on a Sanborn recorder, which indicates spin, tumble, stage firings and other physical movement by a series of peaks and valleys inked on to a moving strip of paper.

The audible signal is recorded on a seven-channel magnetic tape recorder for frequency analysis. Another recording is in digits printed on paper tape.

For quick transmission to other agencies, the signal also is recorded on punched tape that can be fed directly into a teletypewriter. This is used in conjunction with the National Aeronautics and Space Administration's computing center in Washington, where a computer is programmed to receive and analyze the tape message automatically.

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3--Astro-Observation Center

The Astro-Observation Center can receive signals in the extremely wide range between 50 and 1,000 megacycles, and its direction finders can point unerringly at any satellite within range, providing valuable direction information, particularly on upshoots.

When a space vehicle is fired from Cape Canaveral, the countdown is received at the Center by long distance telephone and teletype, and the signal is received in less than five minutes after launch. West Coast firings are seldom heard before several hours have elapsed because their orbits do not bring them within "line-of-sight" range at first.

Aside from antennas, the Astro-Observation Center's equipment has been set up with an eye to easy observation, both by operators and official observers. Receivers, converters, tracking filters and so on are arranged in a long curve, or quarter-circle, easily visible from observation posts behind a plate glass partition, which keeps the operators insulated from outside noises.

Progress announcements can be made to observers over a public address system, and questions to the engineers can be put in through individual microphones leading to a central control console set up between the plate glass and the equipment quarter-circle. This efficient observation deck can also be made available to representatives of the press, radio and TV, when appropriate.

The Diana equipment, well known for its pioneering achievement in bouncing the first radar signals off the moon in January, 1946, has been in constant use since that time. Included in its achievements are valuable studies in radio propagation and space communications; radio contact via the moon with England, Holland and West Germany, and the calibration of the satellite-watching minitrack stations set up between Maryland and Santiago, Chile, to observe the actions of U. S. and foreign space vehicles.

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The following questionnaire was submitted by John Mason of Electronics Magazine (McGraw-Hill). Information for responding was provided mainly by Mr. Manamon and Mr. Zweigbaum.

Q. (Numbers 1 and 2 combined). What part does the Astro-Observation Center play in the national space program; what types of vehicles are tracked?

A. The Astro-Observation Center is operated by the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J. It comprises two main sites, the Deal station and the Diana site, at the Laboratory's Evans Area, some six miles from Deal.

The Deal station performs two broad functions: satellite and missile tracking, and ionospheric research.

As a ~~member of~~ participant in the National Space Surveillance Network, the Deal station tracks U. S. and ~~foreign~~ Russian satellites and deep space probes. ~~All~~ Many missile and satellite launchings to the northeast from Cape Canaveral, whether made by the Department of Defense or the National Aeronautics and Space Administration are monitored. "Quick-look" doppler readings on rocket stage firings are provided. This information is, of course, of great help

in arriving at an early determination on whether a successful orbit is likely to be achieved. This type of service is provided NASA upon request, for example, during the continuing series of Explorer satellite launchings.

Doppler is read out automatically on punched tape at the rate of 60 characters per second. The frequency standards used at Deal in connection with precise doppler measurements are the best obtainable. These standards are compared continuously with an Atomichron in the Frequency Control Division at the main Laboratory building and corrections made to the accuracy of the Atomichron, which is 1: 10^{-11} over a 24-hour period.

The Astro-Observation Center has the use of a 50-foot paraboloid antenna (Diana) and a 60-foot dish at the Evans Area. These, notably the 50-foot antenna, are connected by wire lines with Deal and are used whenever additional antenna gain is needed during deep space probes.

As you probably know, one of the two Army Courier read-out stations was established at the Deal site, but as a separate function. ~~This station was operated by personnel from the Signal Laboratory and Federal Electric Corp. (subsidiary of IT&T.)~~

(Courier was launched 4 October 1960. It handled 118,000,000 (million) words of text and 60 facsimile photographs before technical difficulties on 22 October halted message transmission back to ground stations. The beacon continues to function and is monitored by the regular Deal station.)

One of the two main read-out stations for the Tiros I and Tiros II meteorological satellites was set up at the Diana site. ~~It was operated by Signal Laboratory and RCA personnel,~~ with the 60-foot dish ~~serving~~ was used as the antenna. (The Tiros satellites were sponsored by NASA; the Signal Laboratory directed construction of Tiros I.)

As a radio propagation research site, the Deal station is utilizing signals from satellites to determine heretofore unknown characteristics of the ionosphere for the general purpose of improving communications in outer space for such time when, for example, communication satellites become operational. The beacon signals from about 20,000 orbits of U. S./Russian and satellites have been recorded on magnetic tape and Sanborn charts for use in this work. With the moon as a passive reflector, the 50 and 60 foot dishes also are used in propagation tests reaching through the ionosphere.

Q(3). What new equipment has been installed in the Astro-Observation Center since September 1959 (the time of Mr. Mason's visit to Deal).

A. A parametric amplifier at the Diana site. The Tiros and Courier read-out stations, as detailed above.

Q(4). What equipment should be improved to keep abreast of the state of the art.

A. The Deal station can presently make doppler measurements on any random frequency up to 1,000 megacycles, and is equipped to extract telemetry on any one of 44 assigned missile frequencies in the 215 to 260 mc band. There is immediate need for UHF precision tracking systems which could measure doppler up to 3,000 mc. As now foreseen, there will eventually be a need for equipment which can measure doppler up to 10,000 mc.

Q(5). What new developments appear most promising?

A. The response to Question 4 would appear to answer this, at least partly.

Q(6). What new techniques are contemplated?

A. It is not possible to provide specific answers on this at the present. For example, limited funds preclude installation of the higher frequency equipment mentioned in Item 4 at this time. But it can be generally stated that improvements will be made in facilities as needs increase and funds are allocated.

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ASTRO-OBSERVATION CENTER, DEAL STATION
18 Aug 60, for Courier briefing [launch unsuccessful]

The site where you are now located is the Deal Section of the Astro=Observation Center, operated by the U. S. Army Signal Research and Development Laboratory of Fort Monmouth, N. J. Another section of the center is located some six miles south of here at the Evans Area of the Signal Laboratory. ~~Located~~ at that site are two large dish-shaped tracking antennas, 50 and 60 feet in diameter. They can be linked to the receivers here at the Deal site, which also has its own antenna systems.

The Deal station has some unique capabilities. Precise doppler measurements can be made on any random frequency up to 1,000 megacycles, in the Ultra High Frequency band. The station is equipped to extract telemetry on any one of 44 assiggned missile frequencies in the 215 to 260 megacycle band.

The station is an important contributor to the National Space Surveillance Center, which has headquarters at L. G. Hanscomb Field, near Boston, and operates a net of some 125 stations flung around the world.

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Due to its geographical location, the Deal station has special value when missiles are fired northeasterly over the Atlantic.

Because of its "quick look" facilities, the station has played an important role in the nation's space programs -- since the Army's Explorer I satellite soared into orbit in January 1958.

By keeping its radio ear tuned to the tracking signal of virtually every satellite launched -- both U. S. and Russian -- valuable data are obtained for helping to rapidly determine exact location and the course of an orbit.

All of the signals are recorded on magnetic tape and charts. This "space age" library, the world's largest, is proving valuable for scientific reference. Through the use of this material, the Signal Laboratory is making advanced studies in radio propagation phenomena. This knowledge will help in the success of space programs of the future. Copies of the material on hand also are made available to universities and other research agencies.

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File Astro Obs Center

Astro Observation Center in N.J. Round-Clock, 7-Day Week Operation

FORT MONMOUTH, N. J.—Almost ever since satellites and rockets became a reality, rather than a gleam in some physicist's eye, the Astro Observation Center near here has been on round-the-clock observation, seven days a week.

Operated by the Institute for Exploratory Research, Division C, the Observation Center is in West Deal, Ocean Township. It is about eight miles from the U. S. Army Signal Research and Development Laboratories, and is linked to the Labs by instrumentation hook-up.

Lloyd Manamon, AOC director, said he now has available more than 20,000 trackings of interesting orbits. It is believed to be the world's most comprehensive collection of such trackings, which are on both Sanborn paper charts and Doppler magnetic tapes.

Trackings on File.

Trackings of almost every satellite launched by the United States and Russia are on file here, and three physicists led by Dr. Peter R. Arendt are constantly going over the data. They are primarily interested in propagation studies and the aging effects on quartz crystals as they pass through the Van Allen radiation belts, Dr. Arendt said.

Missions of the Observation Center, as set forth by Mr. Manamon, are to:

1. Extract radio propagation data using signals transmitted from earth satellites and space probes;
2. Act as tracking station for rocket shots from Cape Canaveral, especially the "quick look" evaluation program for the Juno II series firings from the Cape by the National Aeronautics and Space Administration.

The quick look, Mr. Manamon explained, is a method of using precision Doppler measurements in determining orbital data for new satellites. The precision of the station is such that the accuracy of the frequency standards used in this operation are accurate to two parts in 10^{11} per day.

This accuracy is possible, he continued, due to the instrumentation hook-up wherein the Observation Center's local frequency standard is phase-locked to the R&D Lab's Atomachron cesium beam frequency standards.

Used to Check Atmosphere.

In addition, Doppler measurements are used for studying atmospheric profile characteristics, which is important to future satellite communication programs.

The West Deal station is capable of reading out telemetry on the standard IRIG channels and can make signal level records which are also used for measuring spin, tumble and yaw of the satellites, Mr. Manamon stated.

The center's equipment is primarily a modified Dop-Lock system, operating on a phase-locked audio-frequency loop and employing tracking filters by Inter-State Electronics Corp., Anaheim, Calif. Automatic readouts are from filters by Dymec System, a division of Hewlett-Packard Co., Palo Alto, Calif., which transform to punch tape at the rate of 60 characters per second.

This tape in turn can be immediately transmitted over teletype circuits to computer centers. In the past, the West Deal station has fed such centers as the George C. Marshall Flight Center, Huntsville, Ala.; Goddard Space Flight Center, Greenbelt, Md., and the Air Force Space Track Center, Colorado Springs.

Antenna systems used vary from high-gain Yagis by Telrex, Inc., Asbury Park, N. J., which are circularly polarized and can be rotated on pedestals for overhead tracking, augmented by a series of ground plane antennas, rotatable helix and military tracking types.

The system in the past for space probe work utilized 50-foot parabolic-type antennas, remotely controlled from the Signal Corps' Evans Area six miles away, Mr. Manamon said.

3 8-Channel Recorders

The station utilizes three eight-channel Sanborn recorders. The audio Doppler time base and other data is recorded on 27-channel Ampex tape recorders. The telemetry equipment and the micro-lock system, both by Hallamore Electronics Co., Anaheim, Calif., are used for deep space probe tracking.

The Observation Center is unique in that by employing the Dop-Lock system it can cover a frequency range of 15kc to 1,000 megacycles uninterrupted, Mr. Manamon stated. The injection frequency for the system is produced by a bank of frequency synthesizers supplied by Rhode & Schwarz of Germany.

Operated since the very early days of Sputnik I in October, 1957, the present facility, which covers 208 acres, was improved in 1959. Concurrently used as a radio receiver testing area for the USAS-RDL, it was established in 1954 as a low-noise area radio receiving site.

The ambient noise figure here is approximately 30 db below one microvolt, Mr. Manamon pointed out, and over-all sensitivity of equipment is on the order of minus 157 dbm.

Observation Center physicists, said Dr. Arendt, now are engaged in calculating inflection and aging of transmitting or oscillating circuits in satellites, based on data obtained from trackings.

"We cannot now say whether aging of the crystal-controlled circuits in satellites is due to cosmic radiation or other factors," he added.

By use of the precision Doppler system, however, they have unexpectedly found that quartz crystals in some missiles have changed either due to acceleration or temperature effects, he said.

As of July 24, Vanguard I, the first satellite with solar batteries, which was launched March 17, 1958, had made its 13,171st orbit. Vanguard I is transmitting on 108.022 megacyles, and amplitude recordings have indicated that one of its six solar cell clusters has been inoperative since last November, Dr. Arendt said.

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